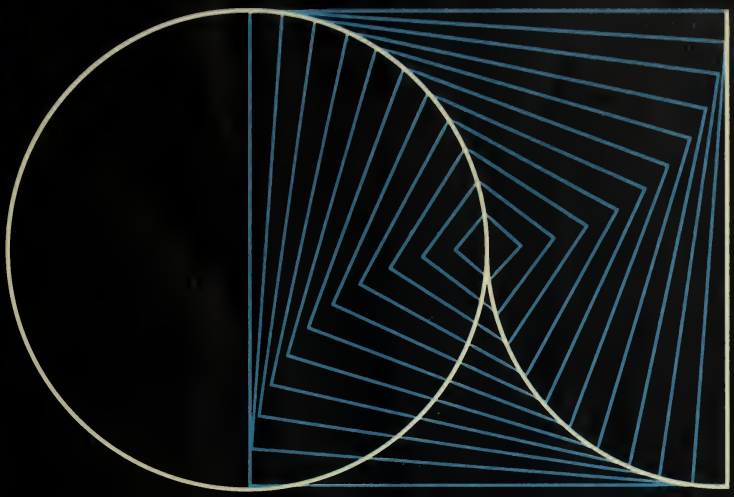

GRADUATE STUDY AND RESEARCH IN Civil Engineering and in Environmental Engineering in Civil Engineering

UNIVERSITY OF ILLINOIS BULLETIN JANUARY, 1971

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A Promising Future
through Graduate Study and Research

GRADUATE STUDY AND RESEARCH IN Civil Engineering and in Environmental Engineering in Civil Engineering

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

JANUARY, 1971

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INTRODUCTION

The University of Illinois at Urbana, Illinois, was founded March 2, 1868, under the Land Grant College Act signed by Abraham Lincoln. In 1870, the College of Engineering was established. In 1871, the Department of Civil Engineering was organized and in 1872, four civil engineers were graduated.

Throughout the past one hundred years, the department has grown and maintained a high position among the best universities in the nation. Such excellence reflects the outstanding quality of the faculty, who offer the best in education at all levels, along with significant research contributions. The American Council on Education, in its 1966 report entitled "An Assessment of Quality in Graduate Education," recognized the distinguished reputation and prestige earned by the department. Graduate departments in all areas, including engineering, were rated and the Department of Civil Engineering graduate faculty was rated "distinguished."

Civil engineers are responsive to the needs of society and are responsible for the solution of problems that will insure the welfare of man in his changing environment. Today's problems and those of the future transcend the historically defined technical areas of engineering, and involve the simultaneous consideration of social, economic, and political implications. Pressing needs of nations require new approaches to the problems of urban housing, construction technology, the planning and coordination of transportation facilities and interfaces, the management of solid, liquid, and gaseous wastes, the provision of adequate air and water supplies, and improved methods for designing against natural hazards (earthquakes, winds, floods, landslides). To meet these needs, new and flexible graduate study and

research programs may be pursued in engineering as well as in other disciplines at the University of Illinois.

Civil engineering offers challenging opportunities to qualified students working towards advanced degrees. Formal course work and participation in creative research enable the civil engineer with graduate training to go beyond the normal limitations imposed by the baccalaureate degree and to be better prepared to contribute more to the progress of his profession. The graduate program places special emphasis on research training in the belief that this is one of the most valuable kinds of scientific engineering experience and training which can be gained by the student.

Recent scientific and industrial developments along with the increasing complexity of many phases of engineering have created a strong demand for civil engineers with formal study beyond that offered in undergraduate programs. Among the fields of work for which graduate study is desirable and for which it prepares the engineer are: advanced analysis and design; consulting engineering practice; teaching of both fundamental and advanced courses in civil engineering, mechanics, and related fields; research and development in industrial laboratories, educational and scientific institutions, and governmental laboratories; and administrative responsibilities in various specialized fields.

This catalog contains essential information for those considering graduate study; however, it is recognized that some of the brief statements may generate questions. On specific problems or questions, students are encouraged to correspond with the:

Head, Department of Civil Engineering
1114 Civil Engineering Building
University of Illinois at Urbana-Champaign
Urbana, Illinois 61801

Advanced study, research, and professional training are offered in the following fields of civil engineering and environmental engineering in civil engineering: Air Pollution . . . Analysis and Design of Structures . . . Behavior of Structures and Properties of Structural Materials (Concrete, Steel, Timber, etc.) . . . Construction Engineering and Management . . . Digital Computer Applications to Analysis or Design . . . Environmental Engineering . . . Geodetic Engineering . . . Highway Engineering . . . Hydrology . . . Hydromechanics and Hydraulic Structures . . . Materials Engineering . . . Models Research . . . Nuclear Structural Shielding . . . Photogrammetry . . . Probability and Stochastic Processes . . . Radiological Health . . . Railway Engineering . . . Rock Mechanics . . . Soil Mechanics

and Foundations . . . Solid Waste Management . . . Stream Analysis . . . Structural Dynamics: Design for Earthquake, Shock, and Blast Excitation . . . Structural Mechanics . . . Systems Analysis and Design . . . Traffic Engineering . . . Transportation: Planning, Systems Design, and Operations . . . Urban Planning and Management . . . Waste Water Treatment . . . Water Quality and Treatment . . . Water Resources.

Because of the extensive research programs directed by members of the staff in these and in related fields, excellent facilities for research are available for use by graduate students.

The degrees of Master of Science and Doctor of Philosophy may be attained by qualified students who satisfy the requirements of the department and the Graduate College. Progress toward an advanced degree is measured not only by the accumulation of units of credit in formal course work but also by evidence of intellectual growth and achievement. The main purpose of graduate study is to enable a student to broaden his knowledge of, and increase his competence in, a given field. Graduate study, especially in the second and third years of the doctorate, aims at the development of independent scholarship, originality, and competence in research, coupled with development of engineering judgment. Training of this type is fostered by close and frequent contact between the student and academic staff. The students' advisers in research and graduate studies in civil engineering are among the most eminent engineering teachers in the country. Because almost all staff members are directly involved in research, and are advisers to a relatively small number of students, close individual contact exists.

Graduate students in civil engineering at the University of Illinois are selected from the top students in the United States and foreign countries. The many domestic and foreign students contribute to the department a variety of experience, which broadens the outlook of all who are included in the graduate group. The knowledge and friendship gained from contact with this select group will be of importance and advantage to the student in his future career.

The large enrollment of students from all parts of the world not only adds to the stature of the department, but also makes it possible to offer a wide range of courses on all phases of civil engineering and environmental engineering in civil engineering.

The number of degrees awarded by the department in recent years is summarized on the following page.

Degrees Awarded	*1968*	*1969*	*1970*
B.S.	101	123	123
M.S.	92	100	108
Ph.D.	33	28	25

Extensive research programs, involving an annual expenditure of almost two million dollars, enable students to participate in active research projects. Research is supported by the University as a part of its educational program for advanced undergraduate and graduate students. However, a large part of the research and graduate program is supported by special grants from various sponsors, including federal and state agencies, technical societies, professional associations, and research councils.

Recent sponsors include American Institute of Steel Construction . . . American Iron and Steel Institute . . . American Society of Civil Engineers . . . Asphalt Institute . . . Atomic Energy Commission . . . Automotive Safety Foundation . . . Defense Atomic Support Agency . . . Department of the Air Force: Special Weapons Laboratory; Rome Air Development . . . Department of the Army: Corps of Engineers; Omaha District; Waterways Experiment Station; Construction Engineering Research Laboratory; Army Research Office — Durham . . . Department of Defense: Office of Civil Defense . . . Department of Health, Education, and Welfare: Public Health Service . . . Department of the Interior: Bureau of Mines; United States Geological Survey; Bureau of Reclamation; Federal Water Pollution Control Administration . . . Department of the Navy: Naval Facilities Engineering Command; Naval Ship Systems Command; Office of Naval Research; Radiological Defense Research Laboratory . . . Esso Research and Engineering Company . . . Great Northern Railway . . . Gulf General Atomic . . . Illinois Central Railroad Company . . . Industrial Fasteners Institute . . . International Lead Zinc Research Organization Incorporated . . . W. M. Lyles Co. . . . National Academy of Sciences-National Research Council: Earthquake Engineering Committee; Highway Research Board . . . National Bureau of Standards . . . National Science Foundation . . . Pennsylvania Central Transportation System . . . Pozzolan Products Co. . . . Raymond Concrete Pile Company . . . Research Council on Riveted and Bolted Structural Joints . . . State of Illinois: Division of Highways . . . United Engineering Trustees Incorporated . . . United States Department of Transportation; Federal Railroad Administration; Federal Highway Administration . . . UNESCO . . . Washington Metro Area Transit Authority . . . Welding Research Council.

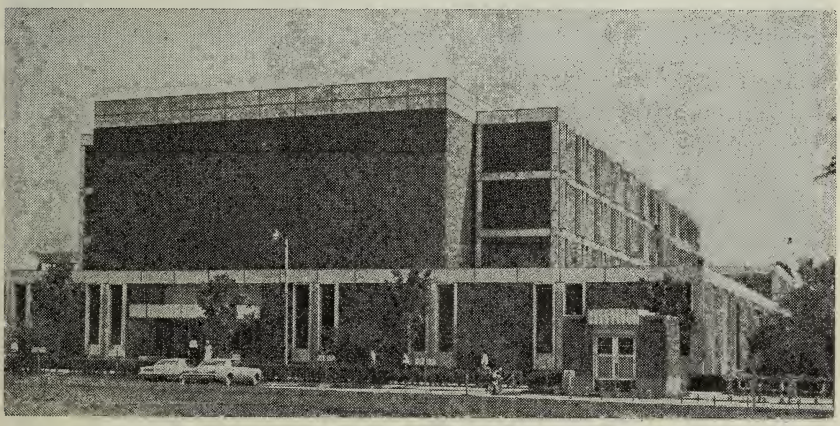
ADMISSION

Admission to the Graduate College with full status in civil engineering or environmental engineering in civil engineering is granted to graduates of institutions whose requirements for the bachelor's degree are substantially equivalent to those of the University of Illinois, provided the applicant's preparation is appropriate to advanced study in his chosen major field and his scholastic average is at least 4.0.[1] This average is computed on the basis of the last sixty semester hours, or 110 quarter hours, of credit recorded.[2] In computing grade-point averages, evidence that the school's grading system is based on a different datum is considered. Under certain conditions applicants with a grade-point average of less than 4.0, and applicants from schools with different grading systems, may be considered if their average is at least the equivalent of 3.75 and evidence is submitted indicating that the applicant's ability is not appropriately measured by the grades submitted. Such applicants should have their application accompanied by at least two letters of recommendation regarding their ability, and by such other evidence that they wish to submit.

Foreign students who rank in the uppermost portion of their graduating

[1] In converting to a numerical grade, the following equivalents are used: A = 5; B = 4; C = 3; D (minimum passing grade) = 2.

[2] All hours of credit are included for all courses in the semesters, quarters, or summer sessions involved in the last sixty semester hours, or 110 quarter hours, of undergraduate work and accordingly the total of hours used in the average may be greater than that noted. Courses failed and subsequently passed must also be included.



The Civil Engineering Building, Urbana-Champaign Campus.

class and who have excelled scholastically are encouraged to apply for admission by forwarding their application and appropriate credentials indicating their academic standing. The prospective foreign student who ranks in the uppermost portion of his graduating class and who excels scholastically will be asked to fill out an application form, *Application for Admission for Applicants from Other Countries,* and submit this along with all supporting credentials, transcripts, etc. The student must also supply information on his rank in his graduating class.

Students must be able to understand and be understood in English, both written and oral. For all students whose native language is not English, the University of Illinois requires a passing score for admission on the test of English as a Foreign Language (TOEFL). Arrangements to take TOEFL in a foreign country may be made by contacting the Educational Testing Service, Box 592, Princeton, New Jersey 08540. This test must be taken well in advance of the expected registration date if the results are to be obtained on time. The results of other English examinations are not acceptable for admission purposes. For foreign students, in most cases a placement examination in English is required at the time of registration on the campus. When indicated by the placement examination, noncredit English courses are prescribed. Registration in these noncredit courses reduces accordingly the number of credit hours for which a student may register; this usually extends the time for completing degree requirements.

The Director of the Office of Foreign Student Affairs (address inside back cover) assists students from abroad with problems involving passports, visas, and other matters. In addition, students must submit evidence of their ability to fully support themselves while in residence at the University.

Students can obtain admission application forms from the Graduate College, the Office of Admissions and Records, or the Department of Civil Engineering. Students should request, if needed, a copy of the University of Illinois Graduate College catalog when the application forms are requested. To avoid delays, a prospective student is urged to submit his application at least three months in advance of the opening of the session in which he plans to enroll, and much earlier than that if financial aid is sought. (For enrollment dates, see calendar on page 51.)

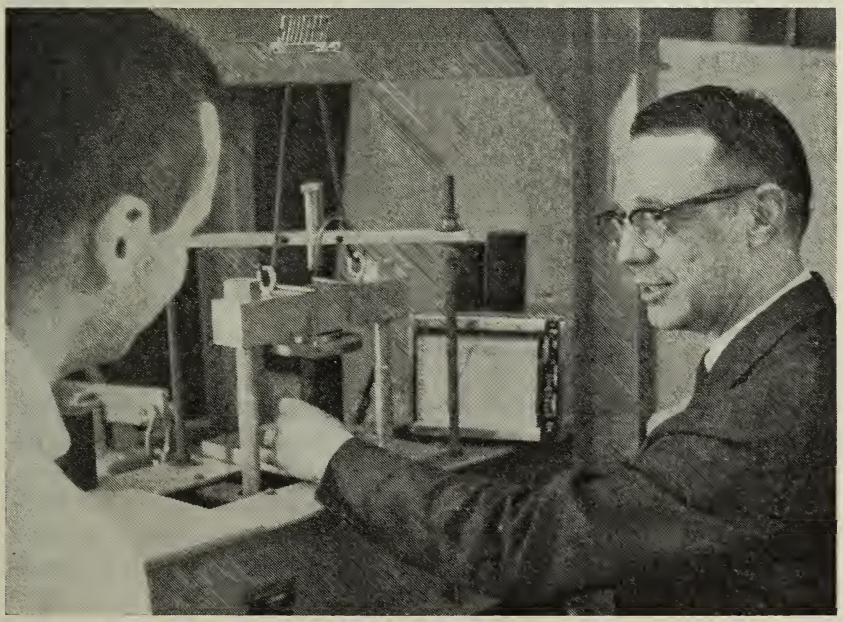
An official transcript from each undergraduate college attended must be forwarded. In addition, all graduate students entering the Department of Civil Engineering should arrange to have one additional set of transcripts forwarded to the department office for its records and use. An

official statement of rank in class, and rank in college, also should be submitted.

Admission to graduate courses may be granted only to those who have had the requisite undergraduate work in those courses. Students without adequate preparation may be required to take, without credit, certain undergraduate courses.

All students must accompany their application for admission with a nonrefundable $15.00 application fee. A student's application for admission and/or financial aid can not be considered or processed until this fee is received.

Admission with Advanced Standing. Upon the recommendation of the Head of the Department and with the approval of the Dean of the Graduate College, admission with advanced standing is granted to applicants who have completed a master's degree or the equivalent elsewhere and who desire to become candidates for the doctor's degree at the University of Illinois. A candidate for admission with advanced standing must meet the minimum standards noted above, and must exhibit an excellent record in his advanced work. The department desires, and may require,



The creep properties of a bituminous mixture are being determined by Professor M. Herrin and a graduate student in the highway materials laboratory.

that a student supply in support of his application for advanced standing an official record of his Aptitude and Advanced Engineering scores in the Graduate Record Examination administered by the Educational Testing Service, Princeton, New Jersey 08540, U.S.A. The record supplied must be for an examination taken during the preceding year.

REGISTRATION AND PROGRAM OF STUDIES

Registration. Dates for registration in the Graduate College are shown on the abbreviated calendar on page 51. Registration material and special instructions are available from the department office during the scheduled registration days or at any time thereafter.

Advisers. Each graduate student is assigned an adviser who assists in planning and carrying through a program of graduate work which fits his needs and satisfies departmental and Graduate College requirements. The adviser for research assistants is normally the staff member in charge of each assistant's research program.

Unit Credit for Courses. Graduate credit is measured in terms of units. One unit is considered the equivalent of four semester hours. The normal program for a full-time graduate student is four units each semester; the maximum permissible is five units. The normal program for an eight-week summer session is two units, with two and one-half units being the maximum permitted. The amount of credit which may be earned in individual courses is indicated in the course listing beginning on page 39.

Work Completed Elsewhere. A candidate for the doctorate who has received a master's degree from a recognized institution enters at Stage 2 with Stage 1 completed. (See page 19.) However, the student is responsible for all work covered previously and will be examined on the content of the courses involved at the time of the preliminary examination.

A student who has done graduate work in a recognized institution, but without receiving a degree, may petition to obtain credit toward an advanced degree by passing examinations in this work. Admission to such examinations requires the approval of the department and of the Dean of the Graduate College. The acceptance of credit for work completed elsewhere does not reduce the residence requirement for an advanced degree.

Upon recommendation of the department, the Graduate College may permit a student to register in absentia for work at a laboratory elsewhere

that offers facilities not available in the Urbana-Champaign area. Such work is accepted for graduate credit if it is completed satisfactorily.

Miscellaneous Courses. A student carrying a normal graduate program may elect, in addition, one miscellaneous course (a course which does not give credit toward an advanced degree). If a graduate student enrolls for more than one miscellaneous course, he may not register for a full graduate program. Courses intended to teach graduate students a reading knowledge of French, German, or Russian are regarded as miscellaneous courses. A student who elects a miscellaneous course is required to register in it and do the assigned work.

Auditing Privileges. A graduate student is permitted to attend classes (other than laboratory courses) as an auditor, provided a form bearing the approval of the instructor and the Dean of the Graduate College is filed with the Records Section of the Office of Admissions and Records. He may not take the same course at a later date for credit.

Graduate Programs for Employed Students. A student who is employed can not expect to complete his academic work as promptly as one who devotes full time to his academic program.

The academic work carried by assistants and others on the University staff is limited by statute. Those employed outside the University are expected to reduce their programs of work in accordance with these regulations. The maximum amount of academic work is determined as follows:

	UNITS OF MAXIMUM REGISTRATION		
	Semester Load		*Summer*
Terms of Employment (Time)	*Normal Load*	*Maximum Overload Petition Required*	*Session Load**
Full time	1 unit	2 units	1 unit
Three-fourths	2 units	2¾ units	1¼ units
Two-thirds	2¼ units	3 units	1½ units
One-half	3 units	3½ units	1¾ units
One-third	3¾ units	4 units	2 units
One-fourth	4 units	4¼ units	2 units
None	5 units	5 units	2½ units

* Maximum load; no overload permitted.

Time Limit for Advanced Degrees. A candidate for the master's degree must complete all requirements for the degree within five calendar years after his first registration in the Graduate College.

A candidate for the doctor's degree must complete all requirements for

this degree within seven calendar years after his first registration in the Graduate College. A candidate who has received a master's degree elsewhere must complete all requirements for the doctorate degree within five years after his first registration in the Graduate College. A student whose program of study is sufficiently interrupted after he receives his master's degree from the University of Illinois, and who later returns to work for his doctorate, will have five years from the date he returns to complete the degree requirements.

Graduate Study in the Summer. A limited number of civil engineering graduate courses are offered during the summer session. The courses offered vary from summer to summer, so that by careful planning, it is often possible to complete the requirements for the master's degree by summer study and make progress toward the doctor's degree. It is not possible to obtain a doctoral degree in civil engineering by attending only summer sessions.

Grades. A minimum grade-point average of 3.75 is required for a student to be certified by the department and the Graduate College as eligible to receive an advanced degree. The details of computing the grade-point average, and the implementation of the requirement, are to be in accord with the Graduate College recommendation of February 19, 1969, as given below.

The grade-point average (GPA) is based on a system where A = 5. Included in the GPA computations are all *units* with grades of A through E. Excluded from the computation are grades of S, U, Pass, Fail, Df, Ex, and Ab; courses taken for semester hour credits; and work not completed on the Urbana-Champaign campus.

At the end of the first term in which a student has completed at least four cumulative units (all units, including Pass, Satisfactory, and credit accepted for work completed elsewhere) with a GPA (based only on units with grades of A through E and excluding credit accepted for work completed elsewhere) of less than 3.75, a warning letter will be sent to the student by the Graduate College with a copy to the department.

A student who has received a warning letter and who has not raised his GPA to 3.75 upon the completion of four additional cumulative units or who at a later time allows his GPA to fall below 3.75, will be sent a disqualifying letter (not eligible for a degree), with a copy to the department.

Pass-Fail Option. The departmental policy regarding courses taken under the Pass-Fail option differs slightly from the Graduate College statement.

In the civil engineering and environmental engineering in civil engineering

programs, the candidate for the master's degree is required to take at least two units of 400-level course work for grades in civil engineering or in a related area of his major. Courses may, with the approval of the student's adviser, be taken on a Pass-Fail basis. For each unit taken on a Pass-Fail basis, three units must be taken for grades on the Urbana-Champaign Campus.

Students may elect the Pass-Fail option *only* during advance enrollment, registration days, or the first two weeks of instruction. Students who elect this option may make changes in their election *only* during registration or the first two weeks of instruction. Request *to elect* this option or *to change* to the option at other times will not be considered.

All students and advisers are cautioned, with respect to the Pass-Fail option, that until other universities throughout the country adopt a similar basis, students having a large number of Pass-Fail courses may not receive adequate consideration for national awards or fellowships or post-doctoral positions at other institutions.

Petitions. The normal procedures and requirements of the Graduate College are indicated in this catalog, but these may be modified occasionally for justifiable reasons. A student may petition for exceptions to various academic and administrative requirements to the Dean of the Graduate College, but he should do so only after consultation with his adviser and with the recommendation of the department. Forms may be secured through the Department of Civil Engineering office.

Multiple Degrees. No more than two graduate degrees will be conferred for work completed at the University of Illinois. This means that a student intending to obtain a doctorate should not enroll for a master's degree in more than one department.

Conferring of Degrees. Advanced degrees are conferred in February, June, August, and October, except the Ph.D. degree is not conferred in August. Not later than two weeks before the degree is to be conferred, each candidate for an advanced degree must obtain and complete a clearance paper from the Graduate College office.

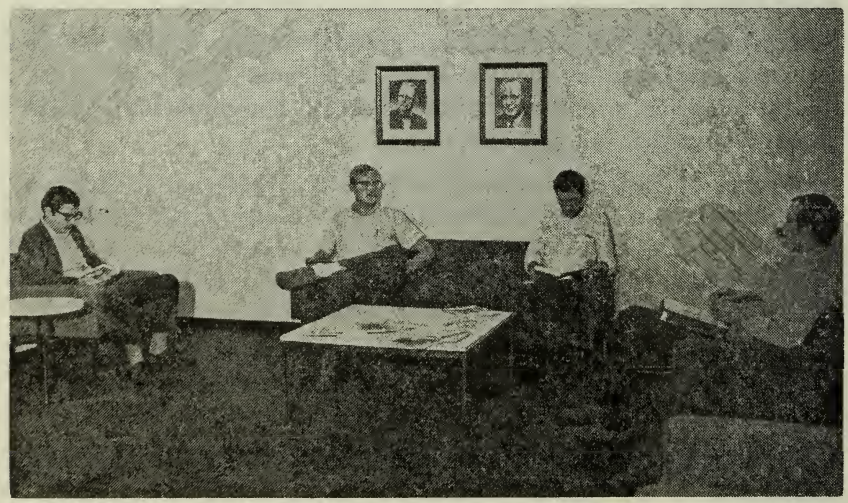
THE DEGREE OF MASTER OF SCIENCE

A Master of Science degree may be completed in one full-time academic year of study.

Credit Requirements. A candidate for the master's degree must complete at least eight units of graduate work with satisfactory grades. Three of the eight units must be in courses numbered in the 400 series, and two of these three must be in the major field. A total of at least four units must be in the major field. When a thesis is not elected or required, the candidate must present at least nine units of course work.

Residence Requirements. A candidate for the master's degree must spend at least two semesters in residence and must earn at least half of the required units while in residence. Attendance during four summer sessions in each of which the student is registered for not less than one unit of work, or in one semester with not less than two units and two summer sessions with not less than one unit each, is regarded as the equivalent of two semesters in residence. Registration for more than two units in a regular semester, or for more than one unit in a summer session, does not shorten the time which must be spent to discharge the residence requirement.

Resident graduate work is important to the student in that he is associated with the faculty and other students who share common interests. In addition adequate libraries, laboratories, and other facilities are available for true scholarly achievements. The atmosphere of inquiry, concentration, and study can be achieved without a division of attention with other work or problems.



One of the student lounges in the Civil Engineering Building. It is named for two well-known faculty members, Thomas C. Shedd and Jamison Vawter.

Foreign Language. There is no foreign language requirement for the M.S. degree. However, during the first year of graduate study, a student who plans to become a candidate for the Doctor of Philosophy degree should qualify in at least one of the languages or alternate requirements shown in the Ph.D. program.

Thesis. If a student elects to prepare a master's thesis or is required to do so by the department, he should file the subject of the thesis at the Graduate College office at least six weeks prior to graduation. No more than three units of thesis credit may be included in an eight-unit program. Credit in thesis research can not be applied to a degree unless a thesis is submitted. For specific instructions with reference to the preparation and form of the thesis, the student should obtain at the Graduate College office a copy of the leaflet *Instructions for Preparation of Theses.*

Thesis Work on Leave of Absence. A student who has completed six units of course work in residence and who wishes to complete the thesis *in absentia* should consult first with his adviser. If the request meets with the latter's approval, a petition is submitted. The petition must include an outline of the proposed investigation and evidence that adequate facilities for pursuing it are available. If the work is to be done in an industrial laboratory, it is necessary to secure a letter from the company releasing to the University all patent and publication rights.

THE DEGREE OF DOCTOR OF PHILOSOPHY

The degree of Doctor of Philosophy, primarily a research degree, is offered in the fields of civil engineering and environmental engineering in civil engineering.

Residence Requirements. A doctoral program includes three stages. At least two of these stages must be completed in residence; the residence period must include two successive semesters in the second or the third stage.

The *first stage* is completed when the candidate has received a master's degree or earns the equivalent number of credits. The *second stage* consists of completion of a minimum of eight units of work, fulfillment of departmental requirements and the language requirements, and a successful preliminary examination. The *third stage* is devoted to research and seminars with a minimum of eight units of credit, preparation of the

dissertation, and the final examination; courses may be taken during this period as well.

It is possible to complete these stages in three years if the student devotes full time to his academic program. For information concerning the maximum time allowed, see page 15.

Majors and Minors. The major area of specialization is a selection of courses which are closely related, but not necessarily offered by the major department. The student is encouraged with the aid of his adviser to arrange his program of study in such a way as to encompass a reasonable number of minor courses which augment his major program of study.

Language Requirements. A candidate for the degree of Doctor of Philosophy has the choice of one of four options that may or may not involve proficiency in a foreign language. The options are subject to the approval of the student's adviser and the Head of the Department as follows:

1. Demonstration of a reading knowledge of one foreign language at a level of proficiency substantially higher than that currently required to pass either the Educational Testing Service (ETS) examination, or French, German, or Russian 401.

2. Satisfactorily complete the equivalent of three units of course work in a field other than the candidate's major, which will complement the student's degree program.

3. Demonstrate a reading knowledge of one language at the present level of proficiency involving a grade of A or B in French, German, or Russian 401, or approved alternatives acceptable to the Graduate College and the department, and one additional unit of course work complementary to the candidate's degree program.

4. Satisfactorily complete two languages at the present level of proficiency, involving a grade of A or B in French, German, or Russian 401, or approved alternatives. Although French, German, and Russian are acceptable in all doctoral programs, candidates may be permitted in some cases to substitute other languages.

Certification of proficiency in foreign languages from other colleges and universities is not accepted by transfer, except possibly through ETS Language Tests. A candidate should qualify in a foreign language if he accepts alternatives 1, 3, or 4, as early in his career as possible and in no case later than two months before the preliminary examination or during the term or summer session preceding admission to the preliminary examination.

Preliminary Examination. A candidate for the doctor's degree must pass a preliminary written (in most areas) and oral examination to test his

knowledge of his major and minor fields of study. He is not admitted to the examination before: (1) he has fulfilled the language or options; (2) he has satisfactorily completed at least sixteen units, exclusive of any language option, of graduate work; (3) the staff of his major and minor fields of study consider that he has adequate preparation.

To maintain his status as a degree candidate, a student who has passed the preliminary examination must register each semester (summer sessions are excluded) until the degree is conferred.

Thesis. The degree of Doctor of Philosophy is primarily a research degree and consequently the candidate must demonstrate his capacity for independent research by preparing an original thesis on a topic within his major field of study. The subject of the thesis must be reported to the doctoral committee and to the Graduate College at the time of the preliminary examination.

When the credit requirement is satisfied (eight units of thesis research subsequent to passing the preliminary examination), the student maintains his status as a candidate by registering for either zero credit in Thesis Research (C.E. 499) or for an appropriate course load until completion of this requirement.

It should not be necessary to submit petitions to the Graduate College requesting that credit in C.E. 499, taken prior to the preliminary examination, be applied to the third stage of the program. In the first place, if the candidate is utilizing any of the facilities of the University, including staff time, he should be registered for appropriate credit (or for the maximum credit allowed under the terms of his contract) until such time as the thesis is completed. Secondly, a candidate who has completed a satisfactory thesis will be admitted to the final examination even though he has not completed eight units subsequent to the preliminary examination, provided he has carried the maximum credit allowed under the terms of his contract during the second and third stages. Thus, the circumstances would have to be most unusual to indicate that a petition of this type would be needed.

Directions regarding thesis form and style are given in the leaflet *Instructions for Preparation of Theses,* copies of which may be obtained in the Thesis Office, Graduate College. The candidate must submit to the Graduate College, no later than the date specified in the current calendar, (1) the original and first carbon (or two copies reproduced by an approved method) of his thesis and (2) one typewritten copy of an abstract of not more than six hundred words. In addition, two copies must be pre-

sented to the major department and one copy should be retained by the author. Arrangements for preparing the thesis should be checked with the student's adviser; the student should check the departmental regulations before drafting the text, tables, and figures.

Final Examination. After the credit requirements for the third stage and the thesis have been completed, the candidate is admitted to the final examination upon recommendation of the major department. A student who has failed to maintain high standards of scholarship and research is refused admission to the final examination. Although the examination is concerned primarily with the research accomplished by the student as described in his thesis, it may extend over the candidate's whole field of study. After successfully completing this stage, a $25.00 microfilm fee is charged which includes publication of the abstract in *Dissertation Abstracts,* and placing a copy of the thesis in the University of Illinois library.

FINANCIAL ASSISTANCE

Financial assistance is available to promising graduate students through fellowships (including traineeships), teaching and research assistantships, tuition and fee waivers, and loans.

Application Procedures. Only one University application form is needed to apply for any or all types of financial aid offered by the University. This one form may be used for fellowships, traineeships, assistantships (teaching or research), and tuition and fee waivers. For the academic year beginning in September, the application and *all* supporting material must be returned to the Head, Department of Civil Engineering, by the preceding February 15. Although applications for assistantships are accepted after that date for any additional openings, applicants for such appointments are strongly urged to submit their papers as early as possible since most awards are offered at the same time that applications for fellowships are considered.

Civil engineering graduate students seeking financial support are required to furnish a statement of rank in class and rank in college. Forms for this purpose are available and are sent with application material. One form is to be filled out and returned by the applicant; the other one is to be filled out and returned by the appropriate school official.

Students may apply for more than one kind of appointment on the application and may indicate an order of preference in a note on the application.

Applicants for financial aid whose native language is not English should note that their applications for admission and financial aid can not be processed until the results of the TOEFL examination are available, and until the $15.00 nonrefundable application fee is paid. Thus the student seeking financial aid should have completed the TOEFL examination well in advance of February 15 preceding admission in September. This is to make sure that the score is on file with the University, so that his application may be considered in the financial aid competition.

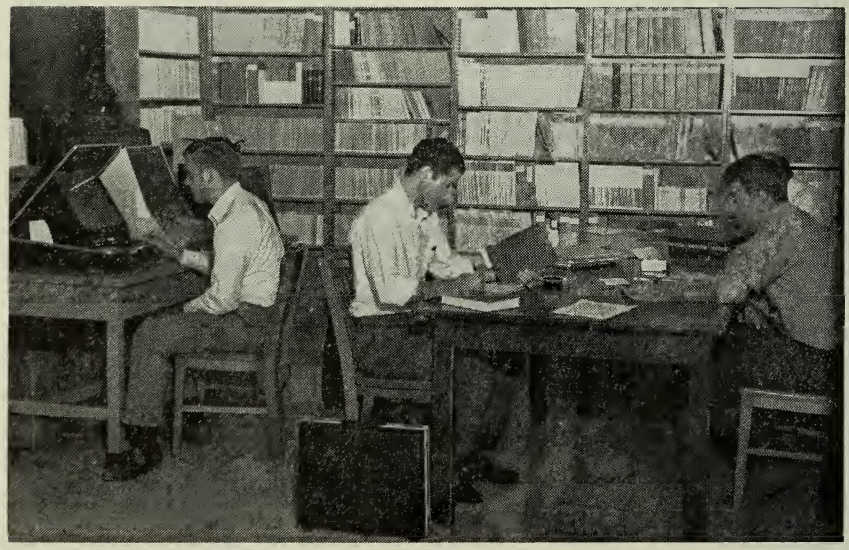
Although it is not a requirement, students are advised that it is to their advantage to take the Graduate Record Examination, and specifically the Aptitude Test (Quantitative and Verbal), and the Advanced Engineering Examination, and have the results forwarded to the Department of Civil Engineering at the University of Illinois. Information as to when and where the Graduate Record Examination is given (generally administered world-wide) may be obtained by writing directly to the Educational Testing Service, Princeton, New Jersey 08540, U.S.A.

Applications for financial aid are available in the Graduate College office, 330 Administration Building, Urbana, Illinois 61801, or from the Department of Civil Engineering.

Fellowships. Fellowship stipends are gratuities awarded in recognition of scholarly achievement and promise and are intended to enable a student to pursue his graduate studies and research without requiring him to render any services. The stipends of different fellowships vary from $2,000 to $4,000 plus a tuition and fee waiver. The fellow's stipend and dependency allowances are legally regarded as gifts, not as compensation for services rendered, and are therefore exempt from income tax. Unless explicitly stated otherwise, all fellows whose appointments are administered by the Graduate College are exempt from tuition and fees. A fellow is required to pursue a full program of graduate study (four units per semester) and may not engage in remunerative employment without the permission of the Dean of the Graduate College. However, most fellows are permitted to hold quarter-time teaching or research assistantships.

Traineeships. Traineeships are virtually equivalent to fellowships since the stipends are considered a tax-free gratuity. The stipends vary, depending on the recipient's level of study and area of specialization. Tuition and fees are also ordinarily covered. No duties are required other than those directly contributing to the training program.

Selection of Fellows and Trainees. Fellows and trainees are selected by the Graduate College Fellowship Committee and/or the department with the approval of the Graduate College on the basis of scholarship and



Publications and helpful services are maintained for students and faculty in the Carl A. Metz Reference Room. Texts, technical reports, symposia, periodicals, audio-visual materials, microfilm and microfiche readers, and convenient study areas are provided for study and research.

promise in teaching and research. The University adheres to the resolution adopted by the Council of Graduate Schools in the United States which provides that if the recipient of an award indicates his acceptance before April 15, he will have complete freedom *through* April 15 to resign in order to accept another appointment. After April 15, however, he may not accept another award without obtaining a formal release from the first commitment.

It is understood that the award of a graduate appointment for one year involves no commitment for continued support by the University for subsequent years.

Departmental Requirements for Fellows. The department requires that all students holding fellowships or traineeships be engaged in some form of active research, either in association with one of the department's formal research programs, or on a special research program with his adviser. All students holding a first-year fellowship or traineeship must arrange to write a master's thesis (C.E. 499), or take at least one unit of Special Problems (C.E. 497), involving a comprehensive report on an individual investigation. This phase of the program provides the student with valuable training and serves as a guide to the department in making decisions about continuing studies and stipends. Second- and third-year fellows necessarily will be involved in research (and should be enrolled for credit accordingly) as a part of their doctoral study.

University Fellowships. These fellowships are based on academic and scholarly achievements, and are unrestricted as to the student's field of graduate study. The recipient may choose either a nine-month or an eleven-month tenure plus exemption from tuition and fees. The department usually augments these fellowships.

Under certain conditions, University Fellows may engage in a limited amount of teaching, not to exceed one-quarter time. University Fellows must carry a full program of four units or the equivalent.

A number of summer fellowships that provide stipends, plus the usual exemption from tuition and fees, are awarded to teaching assistants. These fellowships are restricted to graduate students who have held teaching assistantships at the University of Illinois for at least half-time for both semesters of the preceding academic year, who have earned not less than two units nor more than six units of graduate credit during that year.

Industrial, Endowed, and Special Fellowships. Various industrial firms, foundations, and private individuals have generously donated funds to support a number of special fellowships for graduate students that provide

stipends from $2,000 upward for an academic or calendar year. The stipends and supplemental allowances of these fellowships are not uniform, except that tuition and fees are usually provided. These fellowships vary from year to year but have included American Iron and Steel Institute Fellowship in structural engineering, American Oil Foundation Fellowships in civil engineering, American Society of Civil Engineering Fellowship in civil engineering management, Automotive Safety Foundation Fellowships in highway transportation engineering, A. E. Cummings Memorial Fellowship in civil engineering, Esso Research and Engineering Company Fellowship in civil engineering, and W. E. O'Neil Civil Engineering Fellowship in civil engineering.

National Science Foundation Traineeships. Under this program, grants are made directly to the participating institutions, who select a specific number of promising individuals for full-time graduate study. Appointments may be made only to citizens of the United States (or native residents of a United States possession) who are enrolled in the graduate program. Trainees must devote full time to programs leading to advanced degrees, and may be appointed for nine- or twelve-month tenure only. Under certain conditions, National Science Foundation Trainees may engage in a limited amount of teaching or research.

National Defense Graduate Fellowships, NDEA Title IV. The University of Illinois Graduate College has a number of National Defense Graduate Fellowships which are financed under Title IV of the National Defense Education Act of 1958 and administered with the cooperation of participating departments. The purpose of the National Defense Graduate Fellowship program is to assist students who are preparing to teach in the nation's colleges and universities. Each fellowship, restricted to citizens or permanent residents of the United States, is for a three-year period to a student beginning his graduate studies, or for one- or two-year tenure for more advanced students filling vacated fellowships.

An NDEA Fellow may accept, if offered, a supplemental quarter-time teaching or research appointment.

United States Public Health Service Traineeships. United States citizens pursuing a graduate degree in public health are eligible for Environmental Health Traineeships.

United States Public Health Service Traineeships pay $2,400, $2,600, and $2,800 for the first, second, and third years past the bachelor's degree. In addition, $500 per year is added for a dependent spouse and for each dependent child. Higher stipends, up to $3,600 per year, are available for trainees with sufficient professional work experience. Stipends for less than

twelve full months are prorated to cover the actual time of training. Tuition and fees are also provided for trainees. The recipient must be planning a career in environmental health to qualify for a traineeship and is permitted to carry a full-time course load.

Stipends are available to students at the M.S. degree level in solid wastes management. The recipient must be planning a career in solid wastes management. The stipend is $2,400 for twelve months, plus tuition, fees, and dependency allowance.

National Air Pollution Control Administration Traineeships — Air Resources. The National Air Pollution Control Administration of the Department of Health, Education, and Welfare has awarded a graduate training grant to the University of Illinois for training candidates for the M.S. degree in the area of air resources. The recipient must be planning a career in the area of air pollution control to qualify for the traineeship. The trainee is required to spend from two to four weeks in a state or local control agency for on-the-job experience as part of the twelve-month M.S. program. The basic stipend level is $3,000 with a $500 allowance for each eligible dependent. Stipends are paid on a monthly basis over a twelve-month period. Tuition and fees are also paid for trainees.

Federal Water Pollution Control Traineeships. Through a grant to the University which is administered by the department, graduate students working in the area of water quality control are eligible for these traineeships if they are United States citizens. Stipends provide the same amounts as the U.S. Public Health Service Traineeships (above).

Tuition and Fee Waivers. These awards, available in limited number, provide exemption from payment of tuition and service fees, but not from the hospital-medical-surgical fee, for the academic year and the summer session immediately preceding or following. A graduate student may apply for a tuition and fee waiver by submitting an Application for Graduate Appointment to this department.

Students holding a tuition and fee waiver award must be in residence at the University and must register for at least three units each semester during the academic year. They may accept part-time or incidental employment not to exceed twenty hours a week. Employment may be at the University or elsewhere.

Veterans who are admissable to a graduate program and who meet certain residence requirements may be eligible for exemption from tuition under the state statute concerning military scholarships. Further information may be obtained from the Director of the Undergraduate Scholarship

Program, Office of Student Financial Aid, 707 South Sixth Street, Champaign, Illinois 61820.

Research Assistantships in the Engineering Experiment Station. The Engineering Experiment Station is devoted to the study of problems of special importance to engineering and to the stimulation and elevation of engineering education. By undertaking a program of graduate study in close association with some one of the projects carried on in the station, the student comes into contact with aspects of his specialty which he would rarely touch in a purely academic study, and thus broadens his outlook.

Half-time research assistantships, with a stipend of at least $2,900 for an academic year of two semesters, are open to graduates of approved technical colleges and universities. Applicants to whom these assistantships are awarded devote one-half of their time to the work of the Engineering Experiment Station and one-half to graduate studies. Each appointment is made for one academic year and normally is extended to permit the requirements for the master's degree to be satisfied. In general, with a half-time assistantship, two academic years of residence are required in order to obtain the master's degree. Half-time work at a comparable rate for two and one-half months is sometimes available during the summer months. Thus, with an academic year half-time and a summer half-time appointment if available, an assistant's annual stipend during the first year could be about $4,000, plus exemption from tuition and fees. Generally, a commitment for a summer appointment can not be made in advance of the spring term preceding the summer session. A limited number of appointments are available, with prior arrangement, that permit completion of work for the master's degree by attending two consecutive summer sessions and the two regular semesters between them, or alternatively in three regular semesters.

Appointments to research assistanships are made only to students with outstanding records. Appointments are given to first-year and second-year graduate students, but only rarely to third-year students who have not previously studied at Illinois.

Students holding academic appointments requiring service for more than 67 per cent time are required to pay tuition and fees. Thus those assistants holding full-time appointments during the summer must pay fees. Those whose appointments range from 25 per cent to 67 per cent of their time receive exemption from tuition and all fees, but not the hospital-medical-surgical fee. Assistants must carry a reduced program of study, as shown on page 15.

Fields of research now active include all the programs shown in the Introduction. Most programs have both experimental and analytical phases, and often both aspects are combined in order to permit broader training. It is usually possible to assign a research assistant to a project in the field of his special interest.

A thesis or research report is required at the master's level for all research assistants. Often the research in which he is engaged forms the basis of his thesis, but his thesis is not restricted to this field. Research assistants generally should register for special problems or thesis research during their first year in order to gain additional experience in their area of research.

Applications for research assistantships should be made to the Head of the Department of Civil Engineering preferably not later than February 15 to be considered for appointments effective the following September. Applications received after this date are considered for any vacancies that may still exist. Although most appointments are made for the academic year beginning in September, some appointments may also be available in February or June.

Teaching Assistantships. In general, the department does not grant teaching assistantships to new graduate students. The normal procedure is to select teaching assistants from the research assistants who have served at least one semester in that capacity. Prospective graduate students who are interested in teaching should apply for a regular research assistantship and subsequently make their desires known to their adviser and to the head of the department.

Other Financial Aids. A number of other sources of support are available, for example, fellowships offered by the American Society of Civil Engineers, the American Institute of Steel Construction, and other organizations. Students are encouraged to apply for such stipends.

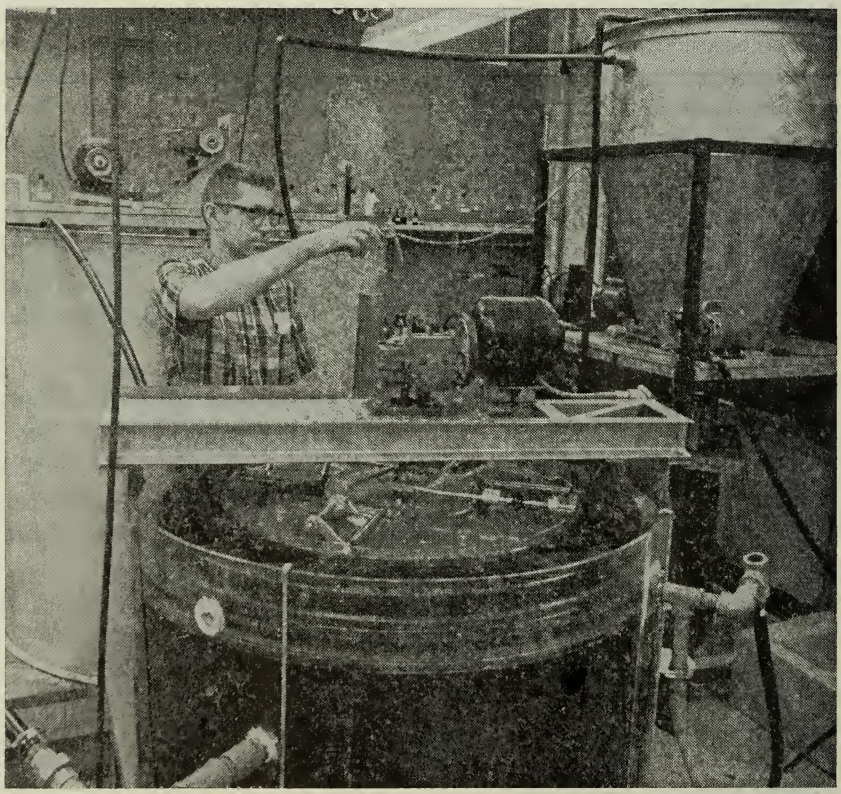
Loan Funds. Information and application forms concerning loans from the University, the National Defense Education Act, the Illinois Guaranteed Loan Program, and the United Student Aid Fund may be obtained from the Student Financial Aids Office, 707 South Sixth Street, Champaign, Illinois 61820. The amount of the loan which is finally approved by the Committee on Loans is subject to the availability of funds and the financial need of the applicant relative to all other applicants. Priority is given to students having the greatest need for financial aid, along with a strong academic background.

University Long-Term Loan Funds may be applied for by graduate students for an amount not to exceed $1,000 per year or a total of $2,500.

Loans are repayable, at a minimum of $30 monthly, at an interest rate of 3 per cent annually, beginning four months after leaving the University, with the requirement that all loans be repaid within four years.

National Defense Education Act Loans are available to eligible graduate students. The limit is $2,500 per year to a total of $10,000. Repayment begins in monthly installments, at an interest rate of 3 per cent annually, nine months after the borrower has ceased to pursue a full-time course of study, and the entire loan must be repaid within ten years after repayment begins.

Up to 50 per cent of a National Defense Education Act loan will be cancelled if the borrower serves as a full-time teacher in a public or nonprofit private school in the United States. This applies to elemen-



A graduate student checks the operation of a pilot plant built to study the treatment of industrial wastes by an activated sludge system employing flotation for separation of the biological solids from the water rather than the conventional gravity sedimentation.

tary or secondary schools and institutions of higher education. Such cancellation will be at the rate of 10 per cent of the loan for each academic year, or its equivalent, of such service. Also, if teaching service is performed in an elementary or secondary school officially classified as having a high percentage of students from low income families, cancellation will be at the rate of 15 per cent per year with no limit on total cancellations.

Wages for Student Employees. Student employment is possible on an hourly basis through the Student Employment Office. The rates for undergraduate students currently range from $1.50 to $3.00 per hour, and for graduate students from $1.80 to $3.70 per hour. New schedules of rates are made in July of each year. Arrangement for student employment can only be made by the student himself when he arrives on campus.

FEES AND EXPENSES

Effective February, 1971, the tuition and other fees indicated herein are payable in full when the student registers, unless the installment plan of payment is elected. An additional charge of $2.00 is made for this privilege.

A partial list of special fees pertaining to graduate students is included below. A complete schedule of tuition, fees, and expenses may be obtained from the Office of Admissions and Records.

Noncredit Courses. Students who register in noncredit courses *on campus* or *in absentia* for doctoral thesis research (Civil Engineering 499) only, without credit, are charged the Range IV tuition and fees for the semester and/or the eight-week summer session.

Persons who register in noncredit seminars, either alone or in addition to other courses, pay the Range IV tuition and fees.

Persons wishing to attend a campus course as a visitor only, pay $15.00 for each course.

Application Fee — $15.00. Each applicant for admission or readmission to the University must submit with his application a nonrefundable fee of $15.00. This fee is not applicable on tuition and other fees.

Late Registration Fine — $15.00. All students, whether on appointment or not, who complete registration for courses on campus after the close of the regular registration, are subject to this fine in addition to the tuition

Tuition and Fees (Effective February, 1971)

Semester II, 1970-1971

	Full Program		*Partial Programs*				
	Range I		Range II		Range III		Range IV
	Above 10 semester hours Above 2½ units		Above 5 through 10 semester hours Above 1¼ through 2½ units		Above 0 through 5 semester hours Above 0 through 1¼ units		0 credit only
	Resident	Non-resident	Resident	Non-resident	Resident	Non-resident	Resident and Non-resident
Tuition (except those holding exemptions)	$198.00	$627.00	$137.00	$430.00	$ 76.00	$236.00	$38.00
Service Fee[1]	40.00	40.00	25.00	25.00	10.00	10.00	5.00
Hospital-Medical-Surgical Fee[2]	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Total	$256.00	$685.00	$180.00	$473.00	$104.00	$264.00	$61.00

Eight-Week Summer Session

	Full Program		*Partial Programs*				
	Range I		Range II		Range III		Range IV
	Above 5 semester hours Above 1¼ units		Above 2½ through 5 semester hours Above ¾ through 1¼ units		Above 0 through 2½ semester hours Above 0 through ¾ unit		0 credit only
	Resident	Non-resident	Resident	Non-resident	Resident	Non-resident	Resident and Non-resident
Tuition (except those holding exemptions)	$ 99.00	$314.00	$ 69.00	$215.00	$38.00	$118.00	$19.00
Service Fee[1]	29.00	29.00	22.00	22.00	8.00	8.00	4.00
Hospital-Medical-Surgical Fee[2,3]	18.00	18.00	18.00	18.00	18.00	18.00	18.00
Total	$146.00	$361.00	$109.00	$255.00	$64.00	$144.00	$41.00

[1] Persons on appointment for at least 25 per cent of full time on the academic, administrative, or permanent nonacademic staff of the University, or on the staffs of allied agencies, and persons registering *in absentia* or in courses conducted off campus are exempt from the service fee. This fee may increase in 1971-1972.

[2] Students presenting evidence of equivalent coverage may receive a waiver of this fee upon approval of a petition submitted to the University Insurance Office not later than the final day established for full refund of fees. A signed waiver and assumption of responsibility is required. Persons registered for thesis research *in absentia* are not assessed this fee.

[3] If insurance coverage for the period between the close of the summer session and the beginning of the first semester is not desired, $9.00 will be refunded if requested in writing prior to the final date established for full refund of fees.

and fees. A student's registration is not complete until his tuition and fees have been paid in full, or he has made arrangement with the Bursar's Office for deferment of payment. Students who register late in any term pay the same tuition and fees as students who register at the beginning of the term.

Microfilm Fee — $25.00. Each candidate who passes the final examination must pay this fee which provides for the microfilming of the complete thesis, with one copy deposited in the University of Illinois Library, and publication of the abstract in the *Dissertation Abstracts*.

Vehicle Registration — $5.00 per year for a motor vehicle and $3.00 per year for a motorcycle, motor scooter, or motor bicycle. All resident students enrolled in the Graduate College who have these motor vehicles in their possession are required to register them with the Motor Vehicle Division. Bicycles also must be registered with this division. No fee is charged for such registration.

Transcript Fee — $1.00. Each student who has paid all his University fees is entitled to receive, without charge, one transcript of his record. For each additional transcript this fee is charged.

Refund of Fees. A student subject to tuition and/or fees who files clearance papers for withdrawal from the University during any semester or summer session, for reasons other than military or other approved national defense service, may receive a refund. Consult the Graduate College catalog for details. (Special refund regulations govern withdrawals for active military or other approved national defense service.)

Residence Classification. The residence classification of an applicant is determined on the basis of information given on his application and other credentials. Tuition is assessed in accordance with this decision. If the student believes he has a legitimate cause for change of status, he may petition, on a form provided by the Office of Admissions and Records, to request a change. Petitions are considered within thirty days from the date instruction begins for the academic period for which the charge is payable. If the nonresident tuition was not assessed on or prior to that date, the claim for refund may be filed within thirty days after the nonresident tuition was assessed and the student was given notice of its assessment. Tuition and fees will not be adjusted for that academic term because of change in residence classification if the petition is not filed within these time limits. If the student expects to ask for a change of residence classification, it is advisable for him to request the adjustment be made prior to the registration period.

Further information concerning residency may be secured by contacting the Office of Admissions and Records, 177 Administration Building, Urbana, Illinois 61801. A brochure entitled *Regulations Governing the Determination of Residence Status for Admission and Assessment of Student Tuition* is also available.

Estimated Expenses for One Academic Year (1970-1971)

	Illinois Residents	*Non-Residents*
Tuition	$ 396.00	$1,254.00
Required fees	80.00	80.00
Hospital-Medical-Surgical fee	36.00	36.00
Textbooks and other school supplies	130.00	130.00
Room and board (men)	1,358.00	1,358.00
Travel to and from home	50.00	102.00
Miscellaneous expenses	522.00	522.00
	$2,572.00	$3,482.00

HOUSING

The University has residence facilities in Arthur Hill Daniels Hall and Stuart Pratt Sherman Hall, two separate residence hall complexes for approximately 1,000 single graduate students, both men and women.

Graduate students living in or near Daniels Hall may contract for their food service (currently $274.00 per semester) in the undergraduate residence hall across the street from Daniels Hall, or at a higher rate, they may pay for each meal on an individual basis. In addition, the University provides a limited number of apartments for married students. Priority in assignment is given to part-time research and teaching assistants, along with the date the completed application is received by the Housing Division. Rates for the residence halls vary from $408.00 to $568.00 per academic year, depending upon the type of accommodations, and can be expected to change upward in the years ahead.

Private housing for either single or married graduate students who may wish to live in privately-owned apartments or University-owned and operated apartments is available. The Housing Division maintains listings of privately-owned apartments and houses in the community.

Applications for accommodations in the University graduate residence halls or the University-owned apartments for married students may be

obtained from the Housing Division, 420 Student Services Building, Champaign, Illinois 61820. The Housing Division also maintains a courtesy list of private apartments and rooms available in homes in the community.

BUILDINGS AND EQUIPMENT

Civil Engineering Facilities and Equipment. During the past few years the Department of Civil Engineering has moved into two new buildings. The main building, the Civil Engineering Building, houses a major portion of the departmental staff and research laboratories, including such areas as structural engineering, soil mechanics and foundations, environmental engineering in civil engineering, materials engineering, construction engineering and management, and systems. The other new building, the Hydrosystems Laboratory, houses staff and research facilities in hydraulics, hydrology, and water resources.

Other units of the department, including transportation (highways, highway materials, railway engineering, and traffic), photogrammetry and geodesy, and certain other special-purpose research laboratories, are housed in nearby buildings on the University campus.

Staff and students in the Department of Civil Engineering have at their disposal a wide range of modern equipment and testing facilities. In recent years the capabilities within many areas of activity have been greatly expanded as a result of new acquisitions.

Instrumentation. All modern items for measuring and recording are available in the department. Two units of equipment are available for automatic logging of static strain gage and other transducer readings. Output data are presented directly and automatically as hard copy and as punched paper tape. In addition, the same data may be fed directly to a data acquisition processing system. This system has, as its heart, a small digital computer which will accept input in the form of manual keyboard, punched paper tape, digital magnetic tape, data from the static logging system described above, and a maximum of sixteen channels of high-speed analog signals from live tests or analog tape recorder systems. Output from this system may be in the form of digital magnetic tape, hard copy, punched paper tape, graphic display on an incremental plotter and line analog signals. The digital tape input-output provides a direct interface access to the University computer system.

Hydrosystems. Permanent equipment in the Hydrosystems Laboratory includes three motor-operated channels, a 30 foot, a 64 foot, and a 156 foot; a diversion and weighing system for in situ calibrations; a wind tunnel to study flow patterns around and forces upon various shaped bodies; and a constant temperature three-channel hot-wire anemometer for the measurement of turbulence in water. The flow system has a total pumping capacity of up to twenty-two cubic feet per second. A watershed facility that is forty feet square, can be controlled with computers for storms up to ten inches of rainfall per hour.

A significant addition to the laboratory is the new re-circulating water tunnel that provides a controllable pressure flow system for the study of a wide variety of cavatation research. The tunnel is also used for experimental model tests and for basic studies leading to the development of improved analytical methods.

Structural Testing. Major structural test facilities consist of a test floor 47 by 135 feet and a special 47 by 50 foot area for heavy reaction research floor. Equipment contained on this floor or in contiguous areas includes: a large batch plant for the preparation of concrete specimens; large machines for the determination of fatigue strength of full-sized as well as scaled structural members; an earthquake simulator; a 600,000 pound capacity servo-controlled hydraulic testing machine; and an assembly of servo-controlled hydraulic rams with appropriate hydraulic pumping capacity and electronic controls.

The earthquake simulator facility consists of an electro-hydraulic system which actuates a twelve foot square platform in one horizontal direction in sinusoidal random vibrations. The platform is designed to carry a 10,000 pound mass at a maximum acceleration of seven times that of gravity.

The servo-controlled testing machine has a static capacity of 600,000 pounds in both tension and compression and a capability to produce dynamic repeated loads of any range between a compression of 400,000 pounds and a tension of 400,000 pounds. The test frame has a 4½ foot clear horizontal distance between vertical columns and 16 foot clear spacing between grips. The machine is provided with hydraulically operated self-aligning grips. Provision has also been made so that this machine may be used to conduct flexural tests on specimens up to 22 feet long. The machine is served by a 70 gallon per minute hydraulic power supply.

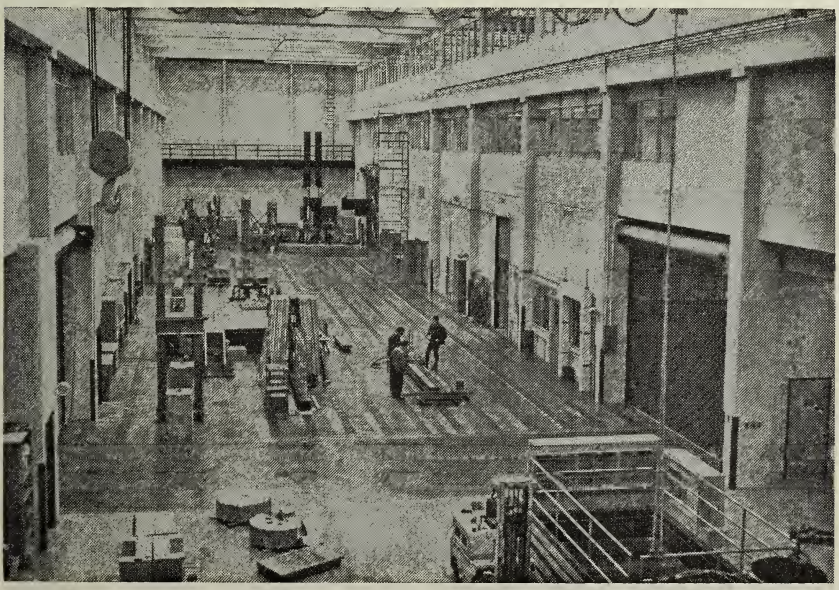
Miscellaneous. Additional equipment available in other areas of the department includes a complete metallurgical facility, stereoscopes, tri-

axial testing assembly, a motorized constant strain shear box, and a hammer seismograph. An X-ray diffraction unit is available for staff and students working on materials problems, as well as access to electron microscopes and other modern equipment. Machine, welding, and wood-working shops are equipped with all types of tools and machinery for the preparation of test specimens. These shops are located adjacent to the major test areas.

Library. The University of Illinois Library ranks first among state universities in its size, and the resources for advanced study and research are outstanding. Its present collections now exceed 4,611,200 volumes. All but about 194,850 of them are located in Urbana.

In addition to the figures for catalogued volumes cited, the University Library contains approximately 552,450 pamphlets, 381,350 maps and aerial photographs, and 333,000 music scores and parts. More than 21,680 periodicals and newspapers are currently received.

The Library's bibliographical facilities comprise a general catalog of more than 6,500,000 cards, a union catalog of titles owned by about two dozen major American and foreign libraries; printed catalogs of libraries, e.g., the Bibliothèque Nationale, British Museum, and Library of Congress;



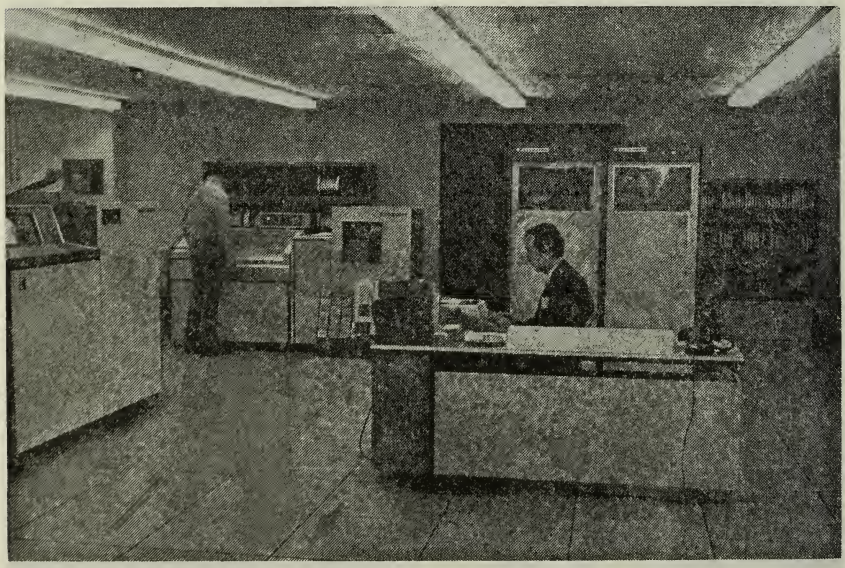
The crane bay has a test floor 135 feet long in which full-size or models of structures or structural members can be tested under various types of conditions and environments.

national and trade bibliographies of all countries for which such works have been issued; bibliographies of special subjects.

Outstanding collections have been developed in the science-technology fields. The Engineering, Physics, Mathematics, Chemistry, and Geology libraries are located near the College of Engineering. Their combined collections include more than 3,600 journal titles and 270,380 books. Graduate students have free access to all library bookstacks. Microreproduction and photo duplication facilities, interlibrary loan service from other institutions for those engaged in research for dissertations, individual reference service, and assistance in using the collections, catalogs, and indexes are also available.

Computational Aids. Available for civil engineering research are various computational aids for use in theoretical methods, studies such as the numerical solution of stress analysis problems, instability, vibration, impact, heat flow, and for data reduction and processing. For advanced study and research, the department has a Burroughs B5500 computer system located in the Civil Engineering Systems Laboratory, Civil Engineering Building.

The Department of Computer Science, located in the Digital Computer



The Civil Engineering Systems Laboratory provides a real-time computer environment which is used for teaching students construction management and for numerous other problems such as structural analysis and design.

Laboratory, has available computing facilities for study use. An IBM computing system 360-75 is available for general University use in research and instruction. Other computers (such as Illiac IV) are under construction. Extensive program libraries are available for the various systems. In addition to general programs, many special purpose programs developed by civil engineering staff members and graduate students are available for the static and dynamic analysis and design of a variety of complex structures, for data reduction, for traffic and equipment allocation studies, for train performance simulation, for planning construction operations, and for many other research problems. Students with no previous program experience may take the non-credit course, Computer Science 400.

The use of these computing facilities make investigations possible involving complex computations which are impracticable or even impossible by other means and greatly expand the scope of both the analytical and design-oriented, as well as some phases of experimental research.

COURSES IN CIVIL ENGINEERING AND IN ENVIRONMENTAL ENGINEERING IN CIVIL ENGINEERING

The prerequisite for graduate work in civil engineering and in environmental engineering in civil engineering is the equivalent of the undergraduate courses required for the degree of Bachelor of Science in the branch of the subject in which registration is desired.

Courses numbered from 300 to 399 are open to advanced undergraduate and graduate students. Those numbered 400 and above are open to graduate students only.

Courses for Graduates and Advanced Undergraduates

304. Fundamentals of Analytical Photogrammetry. An introduction to the basic principles, procedures, and methods of analytical photogrammetry, including relative and absolute orientation, and strip and block adjustment. ¾ or 1 unit. Prerequisite: Civil Engineering 203 and 306, or consent of instructor.

305. Observational Astronomy. Same as Astronomy 314. Astronomical coordinate systems and transformations; theory of, and practice in, approximate and precise determinations of latitude, longitude, and time; introduction to theory of errors; theory and practice of astronomical photography. 1 unit. Prerequisite: Astronomy 102 or 210, or Civil Engineering 201; Mathematics 140, 141, or 145.

306. Adjustment of Observations. A study of the methods of least squares and its application to the adjustment of photogrammetric and geodetic problems; formation and solution of the normal equations, including the use of matrix algebra; types of adjustments including adjustments for hybrid systems; discussion of the normal distribution and the statistical foundations of the method of least squares. ¾ or 1 unit. Prerequisite: Mathematics 315 and Civil Engineering 202, or consent of instructor.

307. Photogrammetric Engineering. A study of metrical photography in civil engineering practice, analytical and analog photogrammetric systems, photometrics and outer space mapping techniques, and automated photographic mapping systems. ¾ or 1 unit. Prerequisite: Civil Engineering 203 or consent of instructor.

309. Geodetic Engineering. Geodetic positioning on a reference ellipsoid, least squares adjustment of first-order triangulation and trilateration nets using observation equations, satellite triangulation, principles and operations of modern instruments, geodetic levelling, map projections, rational design of geodetic systems. ¾ or 1 unit. Prerequisite: Civil Engineering 201 or consent of instructor.

314. Fundamentals of Systems Approach. Introduction to the application of linear programming, network theory, and queueing theory to the synthesis of civil engineering systems. ½ or 1 unit. Prerequisite: Civil Engineering 292 or consent of instructor.

315. Construction Productivity. Introduction to the application of scientific principles to the measurement of and the forecasting of productivity in construction engineering; conceptual and mathematical formulations of the labor, equipment, and material factors affecting productivity. ½ or 1 unit. Prerequisite: Civil Engineering 216 or consent of instructor.

316. Construction Planning. Introduction to the application of scientific principles to the normative planning of construction operations. ½ or 1 unit. Prerequisite: Civil Engineering 216 or consent of instructor.

318. Construction Cost Analyses and Estimates. Introduction to the application of scientific principles to costs and estimates of costs in construction engineering; concepts of and statistical measurements of the factors involved in direct costs, general overhead costs, cost mark-ups and profits; the fundamentals of cost recording for construction cost accounts and cost controls. ½ or 1 unit. Prerequisite: Civil Engineering 216 or consent of instructor.

321. Bituminous Materials and Mix Design. Properties and control testing of bituminous materials; analysis of bituminous paving mixtures; composition and design of asphaltic concrete and soil-asphalt mixes. ½ unit. Prerequisite: Civil Engineering 214 and 220, or consent of instructor.

322. Development of Highway Facilities. Analysis of factors in developing a highway transportation facility; traffic estimates and assignment; problems of highway geometrics and design standards; planning and location principles; intersection design factors; street systems and terminal facilities; programming improvements; drainage design; structural design of surface; concepts of highway management and finance; highway maintenance planning. 1 unit. Prerequisite: Civil Engineering 220 or consent of instructor.

325. Highway Traffic Characteristics. Vehicle operating characteristics; driver characteristics; pedestrian characteristics; roadway characteristics as they individually, and collectively as traffic stream characteristics, are related to the planning, design, and operation of highway facilities. ½ unit. Prerequisite: Civil Engineering 220 or consent of instructor.

333. Urban and Regional Transportation. Importance of transportation and its relation to urban and regional planning; problems of demand; characteristics of transport systems; transportation planning including surveys, data analysis, and problems of administration and finance; coordination and integration of transport. ½ or 1 unit. Prerequisite: Consent of instructor.

334. Airport Design. Basic principles of site selection for airports and fundamental considerations of design, construction, and maintenance of airport pavements and structures. ½ or 1 unit. Prerequisite: Civil Engineering 220 and senior standing in civil engineering, or consent of instructor.

335. Railway Construction and Maintenance. Loads and load distribution on track and subgrade; roadbed construction and stabilization; track stresses, design, and materials; turnouts and crossings; maintenance programs. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

336. Railway Location and Operation. Influence of traffic, alignment, distance, gradients, and motive power upon operating expenses; mechanics of train operation; economic design of location. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

337. Signals. Train movements; systems of signals; track circuits; track capacity; interlockings; economics of signaling. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

338. Terminals. Design and operation of freight terminal facilities for rail, highway, air, and water carriers; passenger terminals and parking lots; terminal requirements for commodity categories; coordination. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

345. Environmental Health Engineering. The application of engineering principles to the control of environmental sanitation and communicable disease control, including administration, biostatistics, epidemiology, vector control, pesticides, milk and food sanitation, swimming pools, individual water supply and wastewater disposal, plumbing, refuse collection and disposal, industrial hygiene and air pollution, radiological health and international health. ¾ unit. Prerequisite: Consent of instructor.

346. Biology of Polluted Water. The significance of biology in water quality, stream pollution, and waste treatment. ½ unit. Prerequisite: Consent of instructor.

348. Air Pollution Seminar. An interdisciplinary seminar on air pollution, including such topics as the health effects, economic damage, and the political,

legal, urban planning, and engineering implications as related to control and enforcement. ½ unit. Prerequisite: Senior or graduate standing.

349. Fundamentals of Radiation Protection. Same as Nuclear Engineering 349. Principles and practice of health physics and radiation protection engineering, including such topics as: principles of dosimetry; sources of ionizing radiation; determination of radiation tolerances; dosimetric instruments; standards and regulations. ¾ or 1 unit. Prerequisite: Nuclear Engineering 397 or Physics 382, or equivalent.

350. Hydrology. An applied course on hydrology dealing with environmental water problems; discussing principles of hydrologic systems and their components; presenting methods of analysis and their applications to various purposes of water resources planning and development. ¾ or 1 unit. Prerequisite: Civil Engineering 255 or equivalent, with consent of instructor.

351. Hydromechanics. Applied fluid mechanics with particular reference to topics in hydraulic design, analysis, and research in civil engineering areas; covers dimensional analysis and dynamic similarity, analysis of potential flow, boundary-layer problems, turbulence and diffusion. Hydraulic transients, water waves, transport phenomena. ¾ unit. Prerequisite: Theoretical and Applied Mechanics 235 or consent of instructor.

352. Water Resources Design. Study and evaluation of phases of river mechanics; water resources history and project implementation; development of a water resources project plan. ¾ unit. Prerequisite: Civil Engineering 255 or consent of instructor.

353. Hydraulic Structures. Introduction to the design of hydraulic structures, including consideration of types and function of dams; hydrologic design; hydraulic design of spillways and outlet works; determination of loads and stresses for concrete structures; seepage, piping, and stability of earth structures. ¾ unit. Prerequisite: Civil Engineering 255 or consent of instructor.

356. Hydraulics of Surface Drainage. Applications of hydraulics and hydrologic principles; elements of channel design, hydrologic determination of design flow; flow through bridge openings and other obstacles; hydraulics of drainage areas; overland flow; runoff from highways; runways and urbanized areas; hydraulics of storm-drain systems; culvert design. ¾ or 1 unit. Prerequisite: Civil Engineering 255 or consent of instructor.

361. Advanced Structural Analysis. A unified development of force and displacement analysis methods for linearly elastic framed structures including introduction to matrix methods of formulation. Applications to plane and space frames and trusses; computer use. ¾ or 1 unit. Prerequisite: Civil Engineering 262 or equivalent.

363. Behavior and Design of Metal Structures, II. Members under combined loads; welded, riveted, and bolted connections; moment-resistance connections; plastic design. ¾ or 1 unit. Prerequisite: Civil Engineering 263 or consent of instructor.

364. Reinforced Concrete Design, II. Limit design of continuous reinforced concrete members and slabs of various types. ¾ or 1 unit. Prerequisite: Civil Engineering 264; credit or registration in Civil Engineering 262.

365. Design of Structural Systems. The whole structural design process including definition of functional requirements, selection of structural scheme, formulation of design criteria, preliminary and computer-aided proportioning, analysis of response, cost and value. 1 unit. Prerequisite: Civil Engineering 263 or 264, or equivalent.

366. Behavior of Reinforced Concrete Members. Ultimate strength and behavior of reinforced concrete members and relation between results of research and current specifications for design; members subjected to flexure, axial compression, combined flexure and axial load, combined flexure and shear, and bond. 1 unit. Prerequisite: Bachelor of Science in civil engineering or architecture with courses in structures and reinforced concrete design.

368. Prestressed Concrete. Principles and methods of linear prestressing; behavior, strength, and design of noncomposite simple beams, composite simple beams, and continuous beams; time-dependent variables and long-time deflections. ¾ or 1 unit. Prerequisite: Civil Engineering 262 and 264.

369. Behavior and Design of Wood Structures. Theory and practice in design of modern wood structures; effect of plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design and the development of design formulae. ¾ or 1 unit. Prerequisite: Civil Engineering 261 or equivalent, or consent of instructor.

374. Introduction to Structural Dynamics. Analysis of the dynamic response of structures and structural components to transient loads and foundation excitation; single-degree-of-freedom and multi-degree-of-freedom systems; response spectrum concepts; simple inelastic structural systems; introduction to systems with distributed mass and flexibility. ¾ or 1 unit. Credit will not be given for both Civil Engineering 374 and Theoretical and Applied Mechanics 311. Prerequisite: Theoretical and Applied Mechanics 212; Mathematics 345; Civil Engineering 261; or equivalent.

379. Applied Structural Mechanics. Study of beams under lateral load; beams with combined lateral load and thrust; buckling; beams on elastic foundations; applications of Fourier series and virtual work principles to beam-type structures; stress and strain in three dimensions; applications to flexure of beams and plates and to constrained torsion; elements of the engineering theory of plates. ¾ or 1 unit. Prerequisite: Mathematics 345 and one undergraduate course in statically indeterminate structures, or consent of instructor.

383. Soil Mechanics and Soil Properties. (Proposed.) Index properties and engineering classification; water flow and hydraulic properties; stress in soil; stress-strain properties of soils; consolidation; shear strength; properties of natural soil deposits; unsaturated soils; experimental measurements. Special section may be offered for students having particular background or a special interest. 1 unit. Prerequisite: Civil Engineering 280 or consent of instructor.

384. Applied Soil Mechanics. Application of soil mechanics to foundations of buildings; stability of earth slopes; earth pressure and retaining walls; braced cuts; damage due to construction operations. ¾ or 1 unit. Prerequisite: Civil Engineering 383 or consent of instructor.

385. Terrain Analysis. Use of geologic and pedologic information and airphoto interpretation techniques in the analysis of terrain for engineering purposes,

correlations among physiographic regions, soil regions and engineering problems. Field trip; estimated expense, $5.00. 1 unit. Prerequisite: Civil Engineering 280 or consent of instructor.

391. Computer Methods in Civil Engineering. Review of programming concepts; formulation and programming of numerical, data-processing, and logical problems with applications to various branches of civil engineering; organization of programs and data; development and use of problem-oriented programming languages in civil engineering. ½ or 1 unit. Prerequisite: Computer Science 101 or 400, or equivalent, or consent of instructor.

Courses for Graduates

403. Analog Photogrammetry, I. Study of the fundamental concepts of the analog approach to photogrammetry; characteristics, capabilities, and limitations of analog photogrammetric data reduction systems; theory of errors of interior and exterior orientation, methods of relative and absolute orientation; model deformations; critical surfaces. 1 unit. Prerequisite: Civil Engineering 203 or consent of instructor.

404. Analog Photogrammetry, II. Two- and three-dimensional aerotriangulation, auxiliary data; propagation of errors; strip and block adjustment; design criteria for aerotriangulation projects. 1 unit. Prerequisite: Civil Engineering 403 or consent of instructor.

405. Analytical Aerotriangulation. Iterative and simultaneous rigorous block adjustment methods, numerical methods for the solution of large systems of equations; characteristics of various analytical photogrammetric systems. 1 unit. Prerequisite: Civil Engineering 304 or consent of instructor.

416. Design of Construction and Industrial Operations, I. Same as Industrial Engineering 416. Conceptual development of a systems design procedure for optimal design of construction and industrial operations; general forms required for critical path networks, linear programs, theory of queues and inventory models required for systems design; design evaluation and control models. 1 unit. Prerequisite: Bachelor of Science in civil or industrial engineering; credit or registration in Mathematics 363; or consent of instructor.

417. Design of Construction and Industrial Operations, II. Same as Industrial Engineering 417. Continuation of Civil Engineering 416. 1 unit. Prerequisite: Civil Engineering or Industrial Engineering 416; credit or registration in Mathematics 315; or consent of instructor.

420. System Approach to Pavement Design. Concepts of system approach; pavement function and performance; evaluation of surface properties and relation to vehicle performance; analysis of subsystems and principal components; composition and properties of pavement mixtures; durability problems and controls. 1 unit. Prerequisite: Bachelor of Science in civil engineering or consent of instructor.

421. Pavement Design, II. Structural design of flexible and rigid pavements; loading characteristics, static, impact and repeated loads; load distribution through pavement layers, factors affecting distribution, methods of analysis;

evaluation of subgrade support; criteria for selecting design values. 1 unit. Prerequisite: Civil Engineering 220 or equivalent.

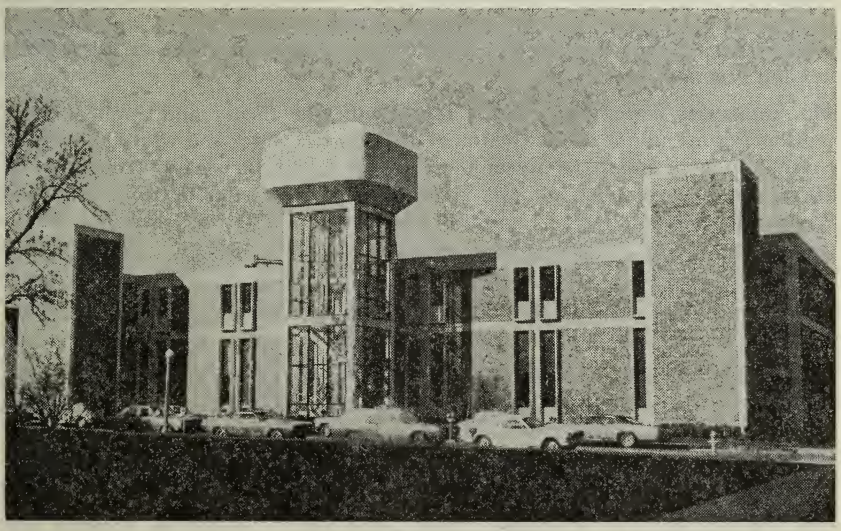
422. Fundamental Properties and Behavior of Bituminous Mixtures. Composition and theories of physical structure of bitumens; rheological, failure, durability, and adhesive properties of bitumens and bituminous mixtures; analysis of factors influencing the performance of bituminous aggregate mixtures. 1 unit. Prerequisite: Civil Engineering 321 or consent of instructor.

423. Highway Materials Stabilization. Stabilization of aggregates and soils with cement, lime, bituminous materials, and other stabilizing agents; basic stabilization reactions, properties of stabilized materials, and composition design are emphasized. 1 unit. Prerequisite: Civil Engineering 220 or consent of instructor.

426. Traffic Planning. Traffic engineering planning functions; urban and rural master traffic plans; traffic analyses for new or existing streets, highways, and terminal facilities. 1 unit. Prerequisite: Civil Engineering 325 or equivalent.

427. Geometric Highway Design. Highway classification; highway capacity; highway design controls; sight distance; horizontal and vertical alignment; cross section elements; highway types; controlled access highways; design of at-grade intersections, grade separations, and interchanges. 1 unit. Prerequisite: Civil Engineering 325 and 426, or consent of instructor.

428. Traffic Engineering Operations. Theory of traffic control; laws and ordinances; design and application of traffic control devices; special street designations; parking design and control; street illumination; miscellaneous traffic control designs. 1 unit. Prerequisite: Civil Engineering 325 and 426, or equivalent.



The Hydrosystems Laboratory is a recent addition to the Civil Engineering Building complex. It is used primarily for study and research in the field of hydraulics, hydrology, and water resources.

435. Railway Construction and Maintenance. Roadbed load capacity; track stresses; economic design of track; economics of maintenance; review of specific projects. 1 unit. Prerequisite: Civil Engineering 335.

436. Railroad Location and Operation. Track and traffic capacity; optimum train size, performance, and scheduling train performance simulation and analysis; optimum size of plant and modern location. 1 unit. Prerequisite: Civil Engineering 336 or consent of instructor.

440. Theory of Water Treatment. Properties of water and criteria of water quality; gas transfer operations in water treatment; chemical treatment processes; corrosion and corrosion control; sedimentation; filtration; disinfection; control of aquatic growths; control of tastes and odors. 1 unit. Prerequisite: Chemistry 122 and Microbiology 101.

441. Analysis and Treatment of Water and Waste Water. Physical, biological, and chemical analysis of water and waste water; field sampling techniques; removal of objectionable impurities, principles of disinfection; determination of dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand; nitrogen, sulfur, and phosphorous compounds in waste waters. 1 unit. Prerequisite: Credit or registration in Civil Engineering 440.

442. Theory of Waste-Water Treatment. Composition, properties, and analysis of wastes; microbiology of waste treatment; pollution of natural waters; sedimentation; chemical treatment; aerobic and anaerobic treatment processes; disposal of waste sludges. 1 unit. Prerequisite: Civil Engineering 346; Chemistry 122; Microbiology 101.

443. Advanced Sanitary Engineering Laboratory. Experimental and pilot plant studies of the operational characteristics for various physical, chemical, and biological unit operations and processes used in the treatment of water and waste water. 1 unit. Prerequisite: Civil Engineering 441; credit or registration in Civil Engineering 442.

444. Industrial Water and Wastes Treatment. The theory and application of unit operations unique to the treatment of industrial water and wastes; advanced consideration of industrial waste problems of major industries; techniques of saline water conversions. 1 unit. Prerequisite: Credit or registration in Civil Engineering 440 and 442, or consent of instructor.

445. Water Quality and Pollution. Water quality standards and criteria for various beneficial uses; transport mechanisms for pollution in surface streams and ground water; fate of pollution and pollution control. 1 unit. Prerequisite: Civil Engineering 250 and 251; Mathematics 345.

446. Design of Water and Waste Treatment Plants. A study of the fundamental factors affecting choice of treatment units and combination of unit processes into an integrated plant. 1 unit. Prerequisite: Civil Engineering 440, credit or registration in Civil Engineering 442, or consent of instructor.

447. Radioactive Waste Disposal. Same as Nuclear Engineering 447. Sources and characteristics of radioactive wastes; methods of treatment; ultimate disposal; fate of radioisotopes in the environment; permissible levels in air and water; current levels in water supplies; water treatment methods; monitoring techniques; solid waste disposal; gaseous wastes disposal; air monitoring; and

reactor site selection and hazards evaluation. ½ or 1 unit. Prerequisite: Physics 282, or Chemistry 398 or Nuclear Engineering 398, or consent of instructor.

448. Control of Air Pollution. A study of air contaminants from all types of sources; deleterious effects of contaminants on plants, animals, and materials; determination of source strength; basic theory of control devices; air pollution surveys; and organization of control programs. 1 unit. Prerequisite: General Engineering 360.

449. Analysis of Air Pollutants. Laboratory analysis of common air pollutants; theory of operation of laboratory and automatic field instrumentation. ½ or 1 unit. Prerequisite: Credit or registration in Civil Engineering 448.

450. Hydrologic Systems. Application of systems concepts to simulate and analyze hydrologic cycle and its components in terms of various deterministic, probabilistic, stochastic, lumped, distributed, linear and nonlinear mathematical models for the purpose of planning and designing water resources projects. 1 unit. Prerequisite: Civil Engineering 350 or consent of instructor.

452. Water Resources. An advanced interdisciplinary course on water resources planning and development; geographic aspects; data collection; governmental functions; hydrologic implications; river hydraulics; hydraulic physical units and water quality; economic aspects; legal, political, and social problems; case studies. 1 unit. Prerequisite: Consent of instructor.

457. Ground Water. An advanced interdisciplinary course on ground water; hydrogeology; hydrodynamics of flow through porous media; ground water hydrology; hydraulics of wells; hydraulic analysis of seepage; ground water pollution; ground water resources. 1 unit. Prerequisite: Consent of instructor.

458. Open-Channel Hydraulics. Basic hydromechanics; flow types; channel characteristics; flow-profile computations; hydraulic jump analysis; design of nonerodible, erodible, and gassed channels and transitional structures; study of supercritical flow and unsteady flow; modern developments in theory and design practice; application of numerical method, method of characteristics, method of singular point, and electronic digital computers and analogs. 1 unit. Prerequisite: Bachelor of Science in civil engineering or consent of instructor.

461. Matrix Formulation of Structural Analysis. Development of structural analysis algorithms in matrix formation: force and displacement vectors and transformations, element property matrices, representation of structures as assemblages of elements, displacement and force methods of analysis, selected advanced topics. 1 unit. Prerequisite: Civil Engineering 361 or equivalent.

463. Optimization of Structures. Structural design processes; formulation of problems in the optimization of structures; optimization of structural elements; minimum volume principles; use of mathematical programming in optimization of structural systems. 1 unit. Prerequisite: Consent of instructor.

465. Structural Design in Metals. Theories of behavior of structural metal members and their components; interpretation of codes and specifications for the design of bridges and buildings. This course and Civil Engineering 475 form a unit in the study of theoretical and experimental investigations. 1 unit. Prerequisite: Bachelor of Science in engineering with courses in structures.

467. Behavior of Reinforced Concrete Structures. Ultimate strength and be-

havior of statically indeterminate reinforced concrete structures; applicability of elastic analysis to framed structures; analysis and design of floor slabs in buildings. 1 unit. Prerequisite: Civil Engineering 366.

469. Thin Shell Structures. Fundamental membrane and bending theories of shells; application of theories to analysis and design of folded plates and cylindrical rotational, and translational shells; membrane stresses and deflections; and approximate bending solutions by variational, finite-difference, and finite-element methods. 1 unit. Prerequisite: Civil Engineering 473 or consent of instructor.

470. Structural Safety and Reliability. Development of concepts and methods of probabilistic structural mechanics relevant to the analysis of structural safety and reliability. Concepts of probability and stochastic processes; statistical considerations of loads and structural resistances; engineering significance of statistical extremes; factor of safety and failure probability; prediction of system reliability; design for safety against natural destructive forces including wind and earthquakes. 1 unit. Prerequisite: Graduate standing; consent of instructor.

471. Numerical and Approximate Methods of Structural Analysis. Methods of successive approximations and numerical procedures for the solution of complex problems with applications to bridges, buildings, and aircraft structures: influence lines, moments and deflections of beams with axial load, buckling strength of columns, moments and deflections of beams resting on elastic or plastic supports, vibration of beams, analysis of arches, moments and deflections of plates, other problems. 1 to 2 units.

473. Analysis and Design of Plates and Shells. Fundamental theories of bending and buckling of plates; practical application of theories in analysis and design of reinforced concrete bridge and building floors, highways and airport pavements, and structural plate components in metal; theory of shells with application to tanks, pressure vessels, shell roofs, and hipped plate construction. 1 to 2 units. Prerequisite: Consent of instructor.

474. Dynamics of Framed Structures. Advanced treatment of the dynamics of multi-degree of freedom framed structural systems. Fundamental concepts of eigenvalue theory of real matrices and energy principles of dynamics as bases for a unified approach to dynamical problems of structural assemblages. Structural idealization, principles of dynamics, Lagrange's equation, response calculations, normal mode method and its limitations, transfer matrix approach; computer utilization. 1 unit. Prerequisite: Civil Engineering 361 or 374, or equivalent.

475. Behavior of Steel Structures. A critical evaluation of the actual behavior of metals, connections, members, and structures; the significance of this behavior in terms of design and the development of design specifications. This course and Civil Engineering 465 form a unit in the study of theoretical and experimental investigations. 1 unit. Prerequisite: Graduate standing in civil engineering or theoretical and applied mechanics.

476. Plastic Analysis and Design. Inelastic behavior of metal structural frameworks; concept of the plastic hinge; collapse configurations; analysis of collapse mechanisms; requirements for stability; deflections, incremental collapse, shake-

down; connections; optimum design; grid frameworks. 1 unit. Prerequisite: Civil Engineering 465 or consent of instructor.

478. Discrete Methods of Solid and Structural Mechanics. Concepts and methods for the discrete formulation and solution of structural and solid mechanics problems. Discrete idealization of solid media and structures by lumped-parameter and finite element approaches; stress analysis and wave propagation in plane and axi-symmetric solids; analyses of plate and shell structures; inelasticity and non-linearity; special boundary conditions; special problems including soil and rock mechanics problems, and structure-medium interaction. 1 unit. Prerequisite: Civil Engineering 379, Aeronautical and Astronautical Engineering 326 or Theoretical and Applied Mechanics 351 or equivalent, and registration in Computer Science 400 or equivalent, or consent of instructor.

480. Earth Pressures and Retaining Structures. Classical and modern earth pressure theories and their experimental justification; pressures and bases for design of retaining walls, bracing of open cuts, anchored bulkheads, cofferdams, tunnels, and culverts. 1 unit. Prerequisite: Credit or registration in Civil Engineering 384.

481. Earth Dams and Related Problems. Fundamentals of problems of slope stability; seepage in composite sections and anisotropic materials; methods of stability analysis; mechanism of failure of natural and artificial slopes; compaction; field observations. 1 unit. Prerequisite: Credit or registration in Civil Engineering 384 or consent of instructor.

482. Advanced Soil Mechanics, I. Theoretical and experimental studies in soil mechanics; stress distribution in homogeneous and stratified soils; theory of consolidation for multidirectional flow, and time dependent loading; numerical methods; secondary consolidation; settlement analyses; experimental measurements. 1 unit. Prerequisite: Civil Engineering 383.

483. Advanced Soil Mechanics, II. Theoretical and experimental studies in soil mechanics; shearing properties of saturated soils; physical properties of partially saturated soils; physico-chemical properties of clays; laboratory direct shear and triaxial shear testing. 1 unit. Prerequisite: Civil Engineering 383.

484. Foundation Engineering. Critical study of case histories of projects in foundation engineering; current procedure for design and construction of foundations, embankments, and water front structures. 1 unit. Prerequisite: Civil Engineering 384.

485. Soil Engineering for Transportation Facilities. (Proposed.) Systems of soil classification; application of statistical methods to soil engineering; relation of mineralogical to engineering properties; soil water migration and volume change. Soil structure and stabilization by connection; soil freezing and pavement behavior; behavior under repeated loading; stability of base of embankment. 1 unit. Prerequisite: Civil Engineering 383 or equivalent.

486. Rock Mechanics. (Proposed.) Physical properties and classification of intact rock, theories of rock failure, state of stress in the earth's crust, stresses and deformations around underground openings assuming elastic, plastic, and time-dependent behavior; effect of geologic discontinuities on rock strength; introduction to stability analyses in rock. 1 unit. Prerequisite: Civil Engineering 383; Geology 450; Theoretical and Applied Mechanics 321.

487. Applied Rock Mechanics. (Proposed.) Application of rock mechanics to engineering problems; shear strength of rock masses; dynamic and static stability of rock slopes; deformability of rock masses; design of pressure tunnel linings and dam foundations; controlled blasting and blasting vibrations; tunnel support; machine tunneling; design and construction of large underground openings; field instrumentation. 1 unit. Prerequisite: Civil Engineering 486.

494. Planning and Management of Urban Unit Systems. The urban unit system, its components, subsystems, and interactions; the planning process, objectives, scope, and phases; the transportation system, objectives and planning; functions, legal authority, and forms of municipal government; organization and management of the political subsystem; municipal finance; building and housing codes; public utilities; recreational development; environmental control. 1 unit. Prerequisite: Graduate standing in any discipline offering courses concerned with urban affairs.

495. Civil and Sanitary Engineering Seminar. Discussion of current topics in civil and sanitary engineering and related fields by staff, students, and visiting lecturers. Course may be repeated. 0 or ¼ unit.

497. Special Problems. Individual investigations or studies of any phase of civil engineering selected by the student and approved by his adviser and the staff member who will supervise the investigation. 0 to 4 units. Prerequisite: Consent of instructor.

499. Thesis Research. 0 to 4 units.

Topics for Civil Engineering 497 (Special Problems)

Regular courses have been established to cover many phases of civil engineering. Even so, students may wish to take advantage of Civil Engineering 497 for special studies. In most areas, extensive use is made of Civil Engineering 497 to cover subjects not always included in the regular courses. Possible topics may be selected within any of the fields of civil engineering or environmental engineering in civil engineering.

COURSES OFFERED IN OTHER DEPARTMENTS

Many of the other departments at the University offer courses for graduate credit which are open to students in civil engineering. A partial list of departments offering such courses are: Agronomy, Biochemistry, Chemical Engineering, Chemistry, Computer Science, Economics, Geography, Geology, Mathematics, Microbiology, Nuclear Engineering, Physics, Sociology, Theoretical and Applied Mechanics, and Urban and Regional Planning.

CALENDAR OF THE GRADUATE COLLEGE

(A detailed calendar of events is given in the Graduate College catalog.)

Second Semester, 1970-1971

Feb. 4, Thurs.-Feb. 6, Sat. to noon	Graduate registration. (Authorization cards distributed on alphabetical basis. Note: Employed school teachers registering for Saturday and evening classes should register Saturday morning, February 6. There will be no registration on Saturday, February 13.)
February 6, Saturday	Last day for registration without payment of late registration fine.
February 8, Monday	Instruction begins.
February 15, Monday	Last day for application for fellowships for 1971-1972.
April 2, Friday	Last day to add a course.
April 3, Saturday, 1 P.M.	Spring vacation begins.
April 12, Monday, 1 P.M.	Spring vacation ends.
April 15, Thursday	Last day for preliminary examination for the Ph.D. degree if thesis credit earned during the semester is to apply to the third stage of program.
April 19, Monday	Last day to drop a course.
April 23, Friday	No names will be added to the June gradution list after this date.
April 30, Friday	Honors Day. Classes dismissed at noon.
May 14, Friday	Last day for candidates for the master's degree in June to submit theses to Graduate College Office for approval of format.
May 18, Tuesday	Last day for candidates for the doctoral degree in June to submit theses to Graduate College Office for approval of format.
May 28, Friday	Last day for candidates for the master's degree in June to deposit theses.
May 30, Sunday	Memorial Day.
May 31, Monday	Memorial Day holiday (no classes).
June 1, Tuesday	Last day for finals for the doctoral degree in June.
June 1, Tues.-June 9, Wed.	Semester examinations.
June 7, Monday	Last day for candidates for the doctoral degree in June to deposit theses and abstracts.
June 19, Saturday	Commencement exercises.

Summer Session, 1971

June 21, Monday.....Graduate registration. (Authorization cards distributed on alphabetical basis.)

June 22, Tuesday.....Instruction begins.

July 4, Sunday.....Independence Day.

July 5, Monday.....Independence Day holiday (no classes).

July 16, Friday.....Last day to add a course.

July 20, Tuesday.....Last day to drop a course.

July 30, Friday.....Last day to apply for National Defense Student Loan funds for 1971-1972. (Early application advisable.)

August 2, Monday,.....Last day for candidates for the master's degree in August to submit theses to Graduate College Office for approval of format.

August 2, Monday.....No names will be added to the August graduation list after this date.

August 12, Thursday.....Last day for candidates for the master's degree in August to deposit theses.

Aug. 13, Fri.-Aug. 14, Sat.....Summer session examinations.

September 15, Wednesday.....Last day for candidates for the doctoral degree in October to submit theses to Graduate College Office for approval of format.

September 20, Monday.....Last day for candidates for the master's degree in October to submit theses to Graduate College Office for approval of format.

September 20, Monday.....No names will be added to the October graduation list after this date.

September 29, Wednesday.....Last day for finals for the doctoral degree in October.

September 30, Thursday.....Last day for candidates for the master's degree in October to deposit theses.

October 6, Wednesday.....Last day for candidates for the doctoral degree in October to deposit theses and abstracts.

First Semester, 1971-1972

September 9, Thursday-September 11, Saturday .....Graduate registration.

September 13, Monday.....Instruction begins.

November 24, Wednesday-November 30, Tuesday.....Thanksgiving vacation.

December 18, Saturday-January 3, Monday ..... Christmas vacation.

January 15, Saturday..... Last day of instruction.

January 17, Monday-January 25, Tuesday ..... Semester examinations.

Deadline Dates for Submitting Applications for Admission or Readmission in September, 1971

July 28, Wednesday..... Last day for foreign students who have not attended a college or university in the United States to apply for admission in September, 1971.

August 25, Wednesday..... Last day for domestic students, or foreign students who have attended a college or university in the United States, to apply for admission or readmission in September, 1971.

Second Semester, 1971-1972

February 3, Thursday-February 5, Saturday ..... Graduate registration.

February 7, Monday..... Instruction begins.

March 25, Saturday-April 3, Monday ..... Spring vacation.

May 12, Friday..... Honors Day (classes dismissed at noon).

May 27, Saturday..... Last day of instruction.

May 30, Tuesday-June 7, Wednesday ..... Semester examinations.

June 10, Saturday..... Commencement exercises.

Eight-Week Summer Session, 1972

June 16, Friday-June 17, Saturday. Registration.

June 19, Monday, 7 A.M..... Instruction begins.

July 4, Tuesday..... Independence Day holiday (no classes).

July 17, Monday..... Beginning of second four-week courses.

August 10, Thursday..... Last day of instruction.

August 11, Friday-August 12, Saturday ..... Summer session examinations.

UNIVERSITY OFFICES

Office of Admissions and Records
100a Administration Building
Urbana, Illinois 61801

Graduate College
330 Administration Building
Urbana, Illinois 61801

Department of Civil Engineering
Civil Engineering Building
Urbana, Illinois 61801

Housing Division
420 Student Services Building
Champaign, Illinois 61820

Office of Foreign Student Affairs
310 Student Services Building
Champaign, Illinois 61820

Student Financial Aids Office
707 South Sixth Street, Room 109
Champaign, Illinois 61820

University offices are open Monday through Friday
from 8:00 a.m. to 12:00 noon and
from 1:00 to 5:00 p.m. except on holidays.